REPORT

OF THE

BOARD OF COMMISSIONERS

OF

ELECTRICAL SUBWAYS,

OF THE

CITY OF BROOKLYN.

DATED DECEMBER 15, 1893.

Including a Special Report, Dated January 29th, 1894.

BROOKLYN:

1894.

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REPORT.

BROOKLYN, December 15th, 1893.

HON. DAVID A. BOODY,
Mayor of Brooklyn.

DEAR SIR:

The Board of Commissioners of Electrical Subways has the honor to submit he following report of work done during the year.

The total length of electrical conductors belonging to different corporations was at the date of the last report (December 10th, 1892), as follows:

MILEAGE OF CONDUCTORS IN BROOKLYN.

American District Telegraph Company	25
Brooklyn District Telegraph Company	50
Citizens Electric Illuminating Company	251
Eastern District Messenger Company	8
Edison Electric Illuminating Company	150
Holmes' Electric Protective Company	9
Municipal Electric Light Company	195
New York and New Jersey Telephone Company	11,987
Postal Telegraph Company	35
Western Union Telegraph Company	311

Brooklyn City Railroad Company (Trolley).
Coney Island and Brooklyn Railroad Company (Trolley).
Atlantic Avenue Railroad Company (Trolley).
Brooklyn City and Newtown Railroad Company (Trolley).

The Trolley systems were in progress of construction and the mileage had not then been reported.

The total length of wires belonging to the City was reported as 370 miles.

The total length of electrical conductors of all kinds within the city limits at this date, December 15th, 1893, is:

	Mileage	
	Aerial.	Underground.
American District Telegraph Company	25	
Brooklyn District Telegraph Company	140	
Citizens' Electric Illuminating Company	265	
Eastern District Messenger Company	12	
Edison Electric Illuminating Company	...	228
Holmes' Electric Protective Company	11	
Municipal Electric Light Company	208	
New York & New Jersey Telephone Company	4,477.47	6,957.98*
Postal Telegraph Company	35	
Western Union Telegraph Company	240	68
Brooklyn Heights Railroad Company (Trolley)	548	164
Coney Island and Brooklyn Railroad Company (Trollery)	21	
Atlantic Avenue Railroad Company (Trolley)	75	
Brooklyn City and Newtown Railroad Company (Trolley)	60	
Stock Quotation Telegraph Company	35	
Fire Department wires	406	

* Inlcuding 2,620.38 miles suspended from the elevated railways.

The increase of mileage of electrical conductors of all kinds during the year has been :

	Aerial.	Underground.
Brooklyn District Telegraph Company	90	
Citizens' Electric Illuminating Company	14	
Eastern District Messenger Company	4	
Edison Electric Illuminating Company	...	78
Municipal Electric Light Company	13	
New York and New Jersey Telephone Company.	156.67	1,873.68
Postal Telegraph Company	...	
Western Union Telegraph Company	...	
Brooklyn Heights Railroad Company (Trolley)	548	164
Coney Island and Boooklyn Railroad Company (Trolley)	21	
Atlantic Avenue Railroad Company (Trolley)	75	
Brooklyn City and Newtown Railroad Company (Trolley)	60	
Stock Quotation Telegraph Company	35	
City wires	41	

The special report of the New York and New Jersey Telephone Company exhibits its total mileage of conductors, together with increase of the same during the past year, as follows:

WIRE IN USE.

	MILES.
In Underground Cables	4,287.53
On Elevated R. R	2,620.38
On Poles	4,101.97
On Housetops	375.50
In Submarine Cable	50.07
Total miles in use	11,435.45

CONDUIT.

Miles of Underground Conduit	23
" " Duct	177
" Elevated R. R. Duct	13.4

OPERATIONS DURING 1893.

Miles of Wire Placed in Underground Cables	1,047.12
" " " on Elevated R. R	826.56
" " " on Poles	156.67
" " Removed from Poles	544.22

THE CONDUITS.

The confidence expressed in former reports in the use of creosoted timber for conduits has been justified by later experience. The durability of the material, when properly prepared, is no longer questioned. The action of a volatile constituent of the creosoting liquid in causing a corrosion of the lead covering of telephone cables was for a time regarded with some anxiety. But this conclusion heretofore expressed is again offered with the greater confidence that is gained by added experience. It may be thus stated: The phenol which in the presence of carbon dioxide rapidly corrodes pure lead, produces but little effect upon the alloy of lead with three per cent. of tin. The phenol, moreover, is volatile and gradually escapes, while the heavier residues remain and prevent decay of the wood.

The Edison Company continues to use the wrought iron tube in which the wires are carefully enclosed in insulating material and which is an inherent part of its system.

THE FIRE DEPARTMENT WIRES.

The Telegraph wires in the service of the Fire Department are owned by the City, and are to be retained on poles until an appropriation is made to cover the expense of an underground system. The Board of Estimate has been repeatedly urged to make provision for a small fraction of the City's wires, but thus far without result. The cost of the entire work of converting the aerial to a subway system is so great that a beginning is not yet attempted. The total length of wire in use by the Fire Department was on Dec. 1st, 406 miles. The cost of construction of conduits and supplying underground conductors for the entire system is estimated by the Fire Commissioner at about one million two hundred thousand dollars.

Some of the City wires formerly carried on poles along Fulton street are now hung upon the Elevated Railway. So that a large number of poles await removal as incumbrances.

THE ARC LIGHT SYSTEMS.

The public demand for extensions of the arc light system for street illumination has led to projected additions to the central stations, and consequently to the distribution of wires. Evidently this Board could not grant permits for any further additions to the overhead system, leading from the central stations, and could only sanction aerial extensions in localities where the street lights had been ordered by the Board of Aldermen and where service from an underground system would not be practicable under the terms of the existing contract with the City.

Negotiations in reference to the location, extent, and kind of subway system which should replace the overhead wires have been in progress for some time. Both the Citizens' Electric Illuminating Company and the Municipal Electric Light Company have submitted plans for an underground service, which have been approved by this Board.

Maps filed by the Citizens' Company showing the route for proposed conduit, and for which permits have been granted indicate a total length of $13\frac{9}{10}$ miles of subway. The permits issued to the Municipal Company cover a length of $14\frac{9}{10}$ miles.

As fast as the work is completed along the specified routes all lighting from pole systems will be prohibited.

The only poles then left standing within such area, bearing electrical conductors will be those belonging to the City.

THE TROLLEY SYSTEMS.

The conversion of horse car systems of street conveyance to the so-called Trolley systems, is nearly complete within the City limits. Citizens are provided with a more comfortable means of street travel, but they are confronted with a new danger to life and limb when, as pedestrians, they cross the Trolley car tracks. So much of the peril as arises from the inexperience of the motor-drivers is gradually becoming less, but all that belongs to the high rate of speed remains as a menace to the peace and comfort of the community. The danger increases in proportion to the increase in velocity. The citizen on foot has greater difficulty in avoiding collision and the motorman has greater difficulty in arresting the motion of his car. Much has been said and written about "fenders" and "wheel guards," but the experience of the last three months leads to the conclusion, that although fenders should not be dispensed with, the most pressing demand now is a more careful regulation of the speed.

If limited to the velocity of ordinary vehicles a Trolley car in the hands of a competent motorman, is no more dangerous than the average express wagon or ice cart, and has as little need of a fender. The track which the car must follow, plainly marks the danger line, whereas the devious track of a reckless driver of a wagon defies human prevision.

It is urged, in behalf of the Trolley, that the rules require the speed to be limited to an average of seven miles, and a maximun of ten miles per hour. But as delays are frequent, and as conductors and motormen are held to be culpable if the average is not maintained, it naturally happens that the motor driver will take advantage of a stretch of clear track, and exceed the prescribed limit of velocity. Cars habitually pass certain points on the principal Trolley lines at the rate of twelve to fifteen miles an hour. In the opinion of this Board, the regulation of the speed is of more urgent necessity than the adoption of an appliance which shall trip and catch or pick up a citizen who is on the track. It is of importance to note that two lives have recently been lost by the impact of the car. The victim was not injured by the wheels. Such safety devices as have been thus far offered, would prove lastingly serviceable only under the condition of a perfectly level and smooth pavement between the rails and for a little distance outside of them. A continuously tinkling bell is also much needed as an additional warning, especially in the busier thoroughfares.

Regulation of the speed can probably be accomplished only by a mechanical governor which will limit the rate of the motor to that required to propel the car at the maximun legal velocity.

The erectiou of guard wires above the Trolley wire has been insisted upon by this Board wherever there was danger of accidental contact with wires of another system. As a further measure of precaution it has been deemed expedient to limit the electric street lights to one side of the streets and avenues traversed by Trolley cars. The ordinary plan of alternating the lamps requires many crossings by wires carrying high tension currents, whereby the danger of contacts is much increased. This change of plan has required that a large number of arc lamp posts be transferred from one curbstone to the opposite one; a work which is yet not quite complete.

The franchise under which the Trolley lines are constructed and operated is construed to include the privilege of stringing the feeder cables along on the poles which are the necessary supports of the Trolly wire. These cables must eventually be put in subways. A plan to bury a group of feeder cables in the southern portion of the City, early in the Summer, was frustrated by the unexpected opposition of the residents who objected on the ground that electric currents under the streets would endanger the health of the neighborhood. The temporary injunction granted by the Court delayed the work of equipping and completing the road, and so far inconvenienced the travelling public that a compromise measure was deemed expedient whereby a part of the system was carried on poles and the remainder on the Elevated Railroad.

CORROSION OF WATER AND GAS PIPES.

One of the inconveniences incident to the introduction of the electric railway system was briefly referred to in the report of this Board for 1892, as of uncertain character and extent. It has proven to be of a very serious nature. This is the corrosion of gas pipes, water pipes and the lead covering of telephone cables. Wherever the destructive action has caused a leak, either of water or gas, the fact has been discovered and the injured section removed. These discoveries have of late been so numerous that there seems no escape from the conclusion that metal pipes of all kinds extending below the surface along the routes of the Trolley cars are being in many places destroyed.

The cause of the difficulty is now well determined. In many other

Cities a similar experience has been recorded. The electrical experts are in accord regarding the origin of the injury. The electric current which propels the cars is discharged through the wheels to the rails. If the latter were continuous conductors the corrosion difficulty would not exist. But the imperfect contacts at the rail joints, even with the best devices for providing a path for the current around the joint, impairs the conductivity to such an extent that the earth in the vicinity becomes charged with the current which was designed for the rails, and plays to considerable extent the part of a return wire. Iron or lead pipes extending along the route below the surface become charged with the current. This condition involves a discharge at some point, and here the electrolytic action is established which, bit by bit, carries away the metal, or rather converts it into a compound which in the moist earth is readily detached. When this action is confined to a limited area, as at an abrupt bend in the pipes, the corrosion is rapid, but when it is distributed along a stretch of several hundred feet, as in the case of a Court street telephone cable recently ruined by this means, the destructive action is slower but is, nevertheless, constant and sure.

A section of iron water pipe recently brought to the office of this Board exhibits a complete perforation which was caused in four weeks. It had been part of a service pipe lying four feet below the Trolley track. It is evident that better means must be provided for the conduction of the return current of the Trolley system. In a few cases, where a rapid local corrosive action has been discovered, the expedient of making a copper connection between the corroding surface and the return conductor between the rails, has been successfully tried.

A more comprehensive plan is in progress of trial on one or two of the electric railways in New England. It consists in welding the rails to continuous length of two thousand or more feet. The success of this experiment is not yet fully assured.

It should be said in behalf of the electricians of the Trolley Companies that there has been no lack of vigilance in aiding to discover the locations of injurious electrical action, or in applying the proper remedy.

In view of the fact that the problem of preventing electrical corrosion to service pipes underlying the Trolley tracks is not yet satisfactorily solved, the proposed extension of electric system under a lately granted franchise may be regarded by the City engineers with some

anxiety, as a portion of the route lies along the line of one of the largest water mains. Not only should absolute protection from electric corrosion be guaranteed by the Trolley Company, but constant watchfulness should be maintained without expense to the City.

A special report on the injury to telephone cables may be found in the appendix.

(Appendix.)

THE NEW YORK & NEW JERSEY TELEPHONE CO.
General Superintendent's Office,
16 Smith Street,
Brooklyn, N. Y., December 13, 1893.

Hon. Board of Electrical Subways, Brooklyn, N. Y.

Gentlemen:

In response to enquiry regarding the action of the escaping Trolley current upon the lead covering of our underground cables I beg to say that five cables have been damaged so seriously, as to cause failure and their removal from the underground conduits on Court street and on Flatbush avenue. Investigation shows that cables on Atlantic avenue, Third avenue, Court street, Flatbush avenue and Manhattan avenue are also affected but not yet seriously. The destructive action is due to electrolysis of the lead cover of the cable, caused by the current which reaches the cable covering through the earth on its way back to the dynamo, leaving the cable at points where the cable is positive to the earth. We have been able in some cases to reduce the trouble by connecting the cables to the return wire of the Trolley road, on poles and underground between the tracks, but as the Trolley system is being rapidly extended, and the location of the source of power and the direction of the current both subject to change, we have had much difficulty in securing tests upon which reliable action can be taken. Along Fulton street, where the Elevated Railroad is used as part of the return circuit for the Trolley current, we have so far suffered no injury, and it is probable that safety can be secured along other routes only by the use on the part of the Trolley roads of copper returns supplementary to the rails of the track, and of *sufficient size* to carry the current which now leaks from the rails through the earth to all other metal conductors; much has been done in this direction by the several roads. Our experience would indicate that the safety of metal pipes of all kind, placed in the earth, as well as economy of operation, requires that the return system should be complete.

Respectfully yours,

J. C. Reilly,
General Superintendent.

SPECIAL REPORT.

Brooklyn, January 29th, 1894.

Hon. Charles A. Schieren,
Mayor of Brooklyn.

Dear Sir:

The Board of Commissioners of Electrical Subways begs leave to submit the following report as an appendix to the annual report submitted December 15th, 1893. It relates to a single subject, viz: the corrosion of water pipes, gas pipes and telephone cables by the return current of the Trolley electric system.

The following report would have formed a part of the earlier communication, but the materials for it were not then obtainable.

The injury briefly referred to in the previous report can now be more completely specified and described by aid of the diagrams submitted herewith.

No. 1. The lead covering of a telephone cable in a conduit near corner of Court street and Fourth place. The cable laid in pitch on the bottom of the duct The pitch proved no protection.

No. 2. The covering of a telephone cable in a conduit on Court street between First place and Fourth place.

No. 3. Another portion of same cable as shown in No. 2.

No. 4. The covering of a cable in a manhole at corner of Atlantic avenue and Smith street. The failure of the cable afforded the first intimation of the injury. A heavy Trolley current had apparently followed the cable and left for the ground at this point.

No. 5. From a cable under the rail of the Fifth Avenue Trolley Line near Flatbush avenue. The same cable was also badly corroded at Bergen street.

No. 6. From a cable between Carroll and President streets in Court street.

No. 7. An iron water pipe which had been in the ground under the Trolley track in Second avenue for about a year.

No. 8. An iron pipe used to replace No. 7 which had been destroyed by corrosion. The indentation and perforation which may be seen near left hand end of the pipe, were produced in thirty days.

No. 9. A lead water pipe taken from four feet below the surface on Second avenue near Fifty-fourth street.

The experience of Brooklyn is not notably different from that of Boston and Cambridge, Mass., Milwaukee, Wis., Columbus O., Indianapolis, Ind., and Hamilton, Ont. In each of these cities similar corrosions have been detected and in none is there any doubt as to the cause. It is known to be due to the imperfections of the means provided by the Trolley Companies for the conveyance of the electrical current back to the generator. It was at first supposed that the rails would be sufficient, but the current declines to take that route exclusively.

The remedy for the evil will have been applied when the Trolley Companies shall have provided an adequate route for the electric current now discharged into the rails. It was at first reasonably supposed that the rails would afford a sufficient path. Upon the failure of this plan, a copper connection to carry the current by the joint was tried. In most cases this expedient failed of complete success, except where the copper bond had unusual dimensions An account of some experiments published in the "Electrical Engineer" may be profitably quoted here. "The resistance per mile of double-track road was found to be 0.7675 ohm in dry earth without bonds connecting the rails. Where the rails were bonded with iron wire of No. 3 gauge and cross-connected without a continuous return wire the resistance was 0.0797 with dry and 0.0717 ohms with wet earth. Where the track was formed with No. 3 copper wire bonds riveted to the rails, each bond soldered to a continuous copper wire of the same gauge and the rails cross-connected every 200 feet the resistance was 0.0207 ohm with wet earth. When the track was made in the same way as in the last example, but further improved by soldering the riveted bonds to the rails and spacing the cross-connections closer together, the resistance when the earth was dry amounted to 0.0254 ohm. Track bonded with two No. 4 galvanized-iron wires without a continuous return wire had a resistance of 0.0577 ohm when the earth was dry.

These figures show that some bond is necessary, and furthermore that the resistance of the rail section is so slight that the calculated resistance of the bonds accounts for nearly all of that observed. This suggests a practical point, namely, the desirability of making the bonds larger than is now the usual practice and omitting the return

wire. The effect of this wire has long been generally acknowledged to be small and its value to be chiefly as a supplement to the bonds. There is a strong tendency now to do away with it entirely. It increases the conductivity of the return circuit somewhat, but probably not as much as if the metal in it were used to make larger bonds. A Johnson section 80, No. 254, girder rail for example, weighing 80 pounds per yard, has about the same conductivity as a copper wire $1\frac{1}{4}$ inches in diameter, while a section H, 60-pound Lewis & Fowler box rail has about the same resistance as a copper wire $1\frac{1}{8}$ inches in diameter. No such amounts of copper have yet been used to make bonds, and until they have the possibilities of rail returns have not been exhausted. If the copper in the return wire in the third kind of track mentioned in the last paragraph were placed in the bonds the latter would be over an inch in diameter instead of 0.23 inch, and the actual conductivity of the return over thirteen fold greater. This shows that water, gas and telephone mains can be protected by better track construction, which will prove as advantageous to the rai way company as to the other interests. This is one of the means of protecting mains from electrolysis, and suggests the following as a second method, which in most cases can probably be applied without much trouble.

This second method is merely the connection by metal circuits of the water mains, gas pipes and telephone cables, to which some electricity will probably always pass, with the generators at the points where there is the least resistance to return currents. These are not necessarily the points where the distance between the pipes and the generators is the shortest, for it is possible to have this shortest line through dry sand and a line nearly a few hundred feet longer through moist earth with less resistance. The electricity of the return current would be apt to leave the pipes at the moist places under such conditions, and it is possible that the return metal circuit should be located here, although somewhat longer than at another point. Old rails, heavily bonded, have been suggested for such a use, and would probably prove satisfactory."

It should be said in regard to this second method, that in making connections with the underground systems of pipes and cables that the points of such connections would require frequent examination. A copper connection with an iron pipe underground would not long remain a reliable conductor, unless special care and watchfulness were given to it.

A better way to insure the conduction of the current is doubtless to make the car rail continuous by welding. This method will be employed on the new Trolley line soon to be built in the southern part of the City.

The most complete solution of the problem is afforded by the double Trolley by which the return current is provided for by an overhead wire similar to the one for the outgoing current. But it is to be hoped that it will not be necessary to resort to this method.

Some notes of experiments obtained through the kindness of Mr. I. H. Farnham, Electrician of the N. E. Telephone Co. and relating to the early experience in Boston are here given.

"When the action of the current was first noticed, the experiment of grounding the cables to lead plates buried in manholes, was tried on quite an extensive scale, but was soon abandoned as being impracticable. The quantity of electricity to be dealt with was so enormous that the buried plates offered no appreciable protection to the cables. If such a system were feasible, the expense for the constant renewal of plates would be very large.

"The severity of the action may be diminished, to a certain limited extent, by so arranging the direction of the current used for the street railways, as to make it pass out over the Trolley wires, and back through the ground. In this way the direction of the current would be quite generally, from the earth to the cables, thus diminishing in certain places the corrosive action. This method would not be a complete protection from the corrosive action, as there would be places where the current would still flow from the cables. Even though the current is uniformly to the earth from the cables, there is the possibility of an action caused by alkaline substances formed about a cable, due to the decomposition by the current from the street cars of the soluble salts contained in the surrounding earth. These alkaline substances are capable, under certain conditions, of dissolving the lead, when the currents are shut off or much reduced, as would be the case at night.

"As there has been some misunderstanding in regard to the potential measurements made in connection with the numerous corrosion investigations, it should, perhaps, be impressed upon those who are about to carry on similar investigations, that the potential measurements between the cables or pipes, and the material surrounding them should, in the majority of cases, only be looked upon as indicating the direction in which the current tends to flow.

"To say that the pipes and cables are even practically safe from corrosion, when the measurements are below a specified figure, would be extremely misleading. These measurements are, in a certain sense, like the measurements which might be made in an electrolytic cell, between one of the electrodes and various portions of the electrolyte, so that it is possible to conceive of almost zero potentials in the immediate vicinity of the most violent electrolytic corrosive actions.

"The fact should be closely borne in mind that whenever we have a current passing from an easily oxidizable metal to the liquid, such as would be encountered in the earth corrosion is bound to occur.

"A large number of electrolytic experiments have been carried out, showing the extremely low potentials (measurements between the electrodes) at which corrosion is found to take place. In many cases iron and lead were destroyed under the conditions encountered in the underground systems at potentials considerably under .5 volt."

The conclusions fairly drawn from these notes and from our own experience is that considerable injury is being done to underground pipes and cables, and that it will continue along the lines of the Trolley roads (except where the Elevated Railway extends above them) until better methods of returning the current to the generator are put in practice.

The electricians of the several Trolley roads are fully aware of the situation and have speedily applied means of prevention in localities where the corrosion had been detected. But it is doubtful if the method of final cure of the difficulty has yet passed the experimental stage.

Respectfully submitted,

GEO. W. PLYMPTON,
FRED. R. LEE,
Commissioners.

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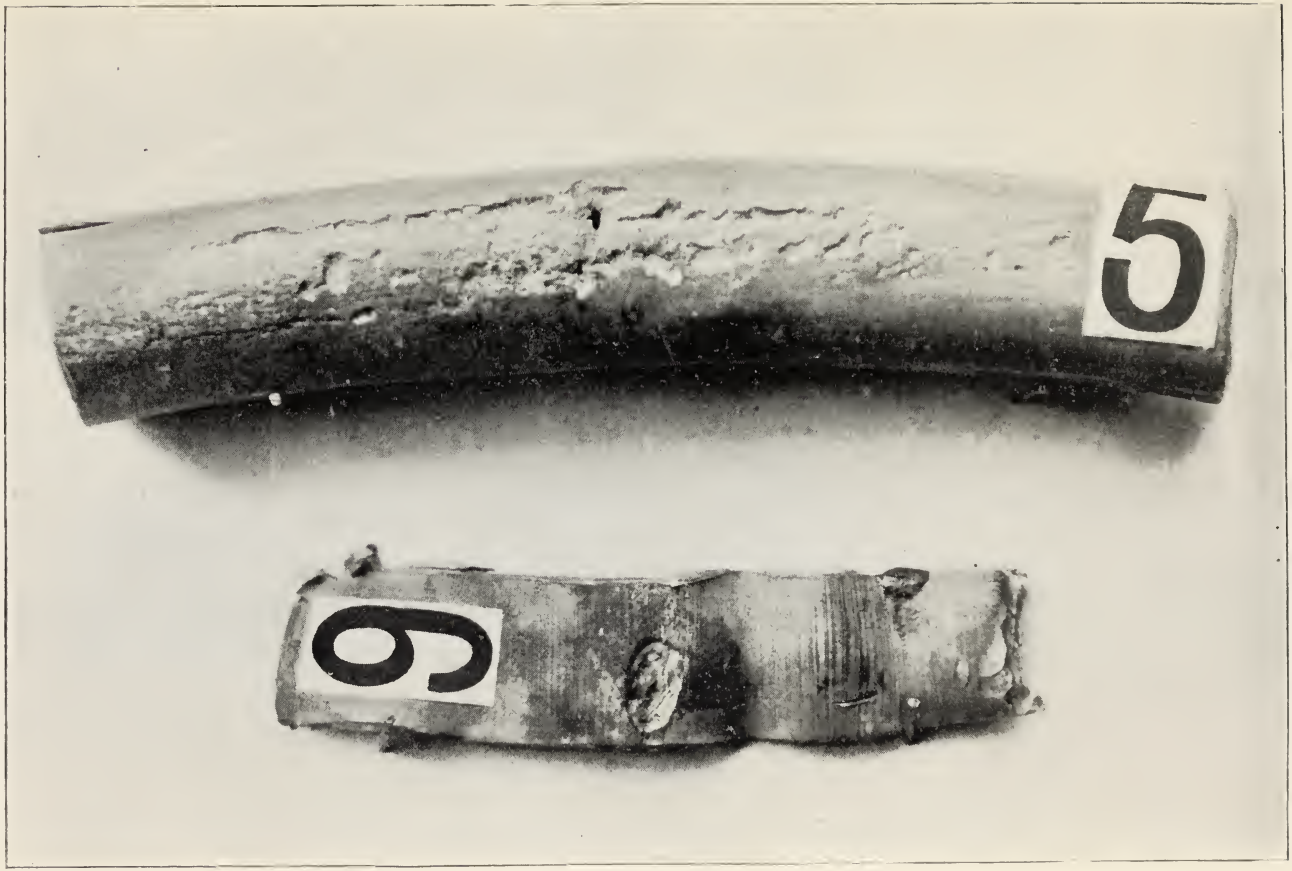
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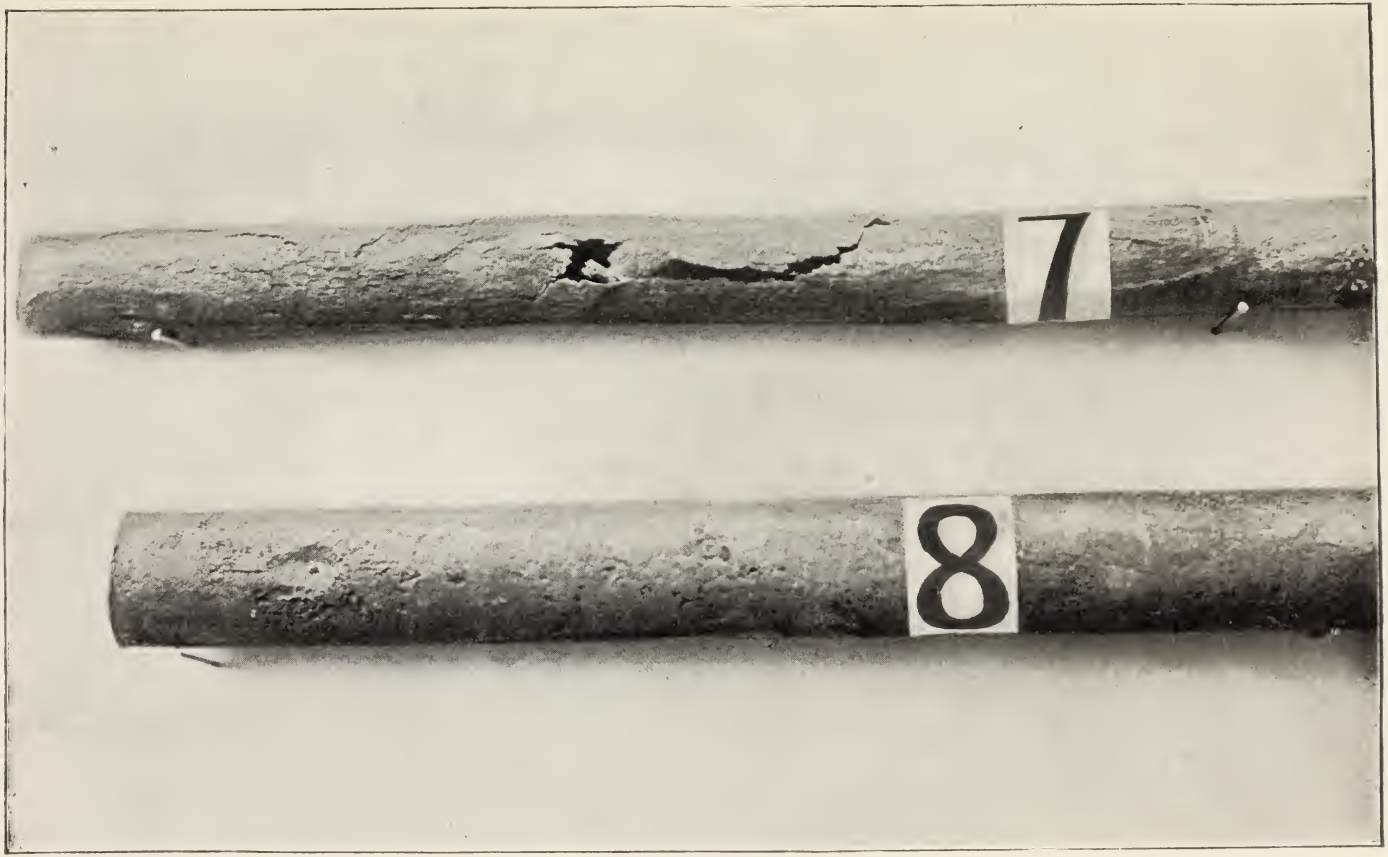
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